Unit 8 - Week 6

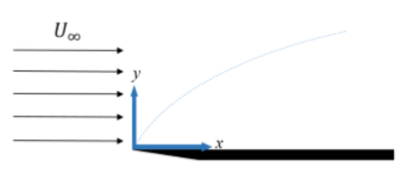
Assignment 6

The due date for submitting this assignment has passed.
As per our records you have not submitted this assignment.

Due on 2019-09-11, 23:59 IST.

1) **Common Data for Questions 1 to 5:** *1 point*

Consider laminar boundary layer flow of a Newtonian fluid of constant density ρ and viscosity μ over a flat plate as shown in the figure below.



The flow ahead of the plate is uniform with velocity $\vec{V} = U_\infty \hat{i}$. Assume the boundary layer theory to be valid. An approximation for the streamwise velocity profile is

$$\frac{u}{U_\infty} = \begin{cases} \frac{3}{2}\left(\frac{y}{\delta}\right) - \frac{1}{2}\left(\frac{y}{\delta}\right)^3 & \text{for } 0 \le y \le \delta \\ 1 & \text{for } y > \delta \end{cases}$$

where δ is the thickness of the boundary layer.

The momentum thickness, θ is given by

(A) $\theta = \int_0^\infty \frac{u}{U_\infty} dy$

(B) $\theta = \int_0^\infty \left(\frac{u}{U_\infty}\right)^2 dy$

(C) $\theta = \int_0^\infty \left(1 - \frac{u}{U_\infty}\right) dy$

(D) $\theta = \int_0^\infty \frac{u}{U_\infty}\left(1 - \frac{u}{U_\infty}\right) dy$

- a
- b
- c
- d

No, the answer is incorrect.
Score: 0
Accepted Answers:
d

2) Which among the following equations correctly represents the momentum integral equation for flow over a flat plate? (τ_w denotes the magnitude of local wall shear stress and δ^* is the displacement thickness) *1 point*

(A) $\frac{\tau_w}{\rho U_\infty^2} = \frac{d\delta^*}{dx}$

(B) $\frac{\tau_w}{\rho U_\infty^2} = \frac{d\theta}{dx}$

(C) $\frac{\tau_w}{\rho U_\infty^2} = \frac{d}{dx}(\theta + \delta^*)$

(D) $\frac{\tau_w}{\rho U_\infty^2} = \frac{d}{dx}(2\theta + \delta^*)$

- a
- b
- c
- d

No, the answer is incorrect.
Score: 0
Accepted Answers:
b

3) The ratio of momentum thickness to the boundary layer thickness, $\frac{\theta}{\delta}$ for the assumed velocity profile is *1 point*

(A) 0.139

(B) 0.375

(C) 0.486

(D) 0.666

- a
- b
- c
- d

No, the answer is incorrect.
Score: 0
Accepted Answers:
a

4) The boundary layer thickness, δ is traditionally expressed in dimensionless form: *1 point*

$$\frac{\delta}{x} = aRe_x^n$$

where x is the distance from the leading edge and $Re_x = \frac{\rho U_\infty x}{\mu}$ is the local Reynolds number. The values of a and n calculated from the momentum integral equation using the assumed velocity profile are

(A) $a = 0.647$; $n = -1$

(B) $a = 0.647$; $n = -\frac{1}{2}$

(C) $a = 1.740$; $n = -1$

(D) $a = 4.64$; $n = -\frac{1}{2}$

(E) $a = 4.64$; $n = -1$

- a
- b
- c
- d
- e

No, the answer is incorrect.
Score: 0
Accepted Answers:
d

5) The wall shear stress is represented in terms of the non-dimensional skin friction coefficient defined as *1 point*

$$C_f = \frac{\tau_w}{\frac{1}{2}\rho U_\infty^2}$$

Using the momentum integral equation, C_f can be expressed in terms of the local Reynolds number as $C_f = bRe_x^m$. The values of b and m calculated using the assumed velocity profile are

(A) $a = 1.740$; $n = -1$

(B) $a = 0.647$; $n = -1$

(C) $a = 0.647$; $n = -\frac{1}{2}$

(D) $a = 4.64$; $n = -\frac{1}{2}$

(E) $a = 4.64$; $n = -1$

- a
- b
- c
- d
- e

No, the answer is incorrect.
Score: 0
Accepted Answers:
c

6) The predominant forces acting on a fluid element within the boundary layer over a flat plate in a uniform parallel stream are *1 point*

(A) Viscous and inertia forces

(B) Viscous and pressure forces

(C) Inertia and pressure forces

(D) Viscous and body forces

- a
- b
- c
- d

No, the answer is incorrect.
Score: 0
Accepted Answers:
a

7) At the point of flow separation for viscous flow past a solid object, *1 point*

(A) axial pressure gradient is zero

(B) wall shear stress is zero

(C) fluid pressure reduces to its vapour pressure

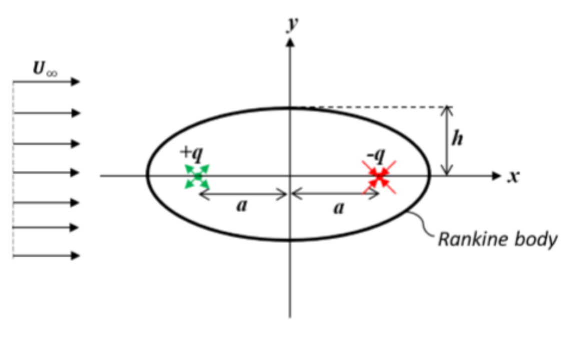
(D) the magnitude of wall shear stress reaches its maximum.

- a
- b
- c
- d

No, the answer is incorrect.
Score: 0
Accepted Answers:
b

8) **Common Data for Questions 8 to 15:** *1 point*

A steady, two-dimensional flow formed by the superposition of a uniform stream of speed U_∞ in the positive x-direction, a source of strength q at $(x, y) = (-a, 0)$, and a sink of equal strength q at $(x, y) = (a, 0)$ where $a > 0$ generates a potential flow past a Rankine body. The pressure far upstream of the origin is p_∞.



The complex potential for a source of volume flow rate q per unit depth perpendicular to the plane located at (x_0, y_0) is

(A) $F(z) = \frac{q}{2\pi z}$

(B) $F(z) = \frac{q}{2\pi} \ln z$

(C) $F(z) = -\frac{iq}{2\pi} \ln(z - x_0 - iy_0)$

(D) $F(z) = \frac{q}{2\pi} \ln(z - x_0 - iy_0)$

- a
- b
- c
- d

No, the answer is incorrect.
Score: 0
Accepted Answers:
d

9) The complex potential for the combined flow field of uniform stream, source and sink is *1 point*

(A) $F(z) = U_\infty z + \frac{q}{2\pi} \ln\left(\frac{z+a}{z-a}\right)$

(B) $F(z) = U_\infty z + \frac{q}{2\pi} \ln\left(\frac{z+ia}{z-ia}\right)$

(C) $F(z) = U_\infty z - \frac{iq}{2\pi} \ln\left(\frac{z+ia}{z-ia}\right)$

(D) $F(z) = U_\infty z - \frac{iq}{2\pi} \ln\left(\frac{z+a}{z-a}\right)$

- a
- b
- c
- d

No, the answer is incorrect.
Score: 0
Accepted Answers:
a

10) The resultant velocity field is given by *1 point*

(A) $\vec{V} = U\hat{i} - \frac{q}{2\pi[(x-a)^2 + y^2]}[-y\hat{i} + (x-a)\hat{j}] + \frac{q}{2\pi[(x+a)^2 + y^2]}[-y\hat{i} + (x+a)\hat{j}]$

(B) $\vec{V} = U\hat{i} - \frac{q}{2\pi[x^2 + (y-a)^2]}[x\hat{i} + (y-a)\hat{j}] + \frac{q}{2\pi[x^2 + (y+a)^2]}[x\hat{i} + (y+a)\hat{j}]$

(C) $\vec{V} = U\hat{i} - \frac{q}{2\pi[(x-a)^2 + y^2]}[(x-a)\hat{i} + y\hat{j}] + \frac{q}{2\pi[(x+a)^2 + y^2]}[(x+a)\hat{i} + y\hat{j}]$

(D) $\vec{V} = U\hat{i} - \frac{q}{2\pi[x^2 + (y-a)^2]}[-(y-a)\hat{i} + x\hat{j}] + \frac{q}{2\pi[x^2 + (y+a)^2]}[-(y+a)\hat{i} + x\hat{j}]$

- a
- b
- c
- d

No, the answer is incorrect.
Score: 0
Accepted Answers:
c

11) The coordinates of the stagnation points if $q = 3\pi U_\infty a$ are *1 point*

(A) $\left(\pm\sqrt{2}a, 0\right)$ (B) $(\pm 2a, 0)$

(C) $(0, \pm 2a)$ (D) $\left(0, \pm\sqrt{2}a\right)$

- a
- b
- c
- d

No, the answer is incorrect.
Score: 0
Accepted Answers:
b

12) There is a closed streamline in this flow that defines the Rankine body. The equation of this streamline if $q = 3\pi U_\infty a$ is *1 point*

(A) $\frac{x}{a} = \frac{3}{2}\tan^{-1}\left(\frac{2ax}{x^2 + y^2 - a^2}\right)$ (B) $\frac{y}{a} = \frac{3}{2}\tan^{-1}\left(\frac{2ay}{x^2 + y^2 - a^2}\right)$

(C) $\frac{x}{a} = \frac{3}{2}\ln\left[\frac{(x+a)^2 + y^2}{(x-a)^2 + y^2}\right]$ (D) $\frac{y}{a} = \frac{3}{2}\ln\left[\frac{x^2 + (y+a)^2}{x^2 + (y-a)^2}\right]$

- a
- b
- c
- d

No, the answer is incorrect.
Score: 0
Accepted Answers:
b

13) The half-width, h, of the Rankine body in the y-direction if $q = 3\pi U_\infty a$ is given by the transcendental algebraic equation: *1 point*

(A) $\frac{h}{3a} = \tan\left(\frac{h}{a}\right)$ (B) $\frac{h}{3a} = \cot\left(\frac{h}{a}\right)$

(C) $\frac{h}{a} = \cot\left(\frac{h}{3a}\right)$ (D) $\frac{h}{a} = \tan\left(\frac{h}{3a}\right)$

- a
- b
- c
- d

No, the answer is incorrect.
Score: 0
Accepted Answers:
c

14) The hydrodynamic drag force on the Rankine body per unit depth perpendicular to the plane if $q = \pi U_\infty a$ is *1 point*

(A) $\pi\rho U_\infty^2 a$ (B) $6\pi\rho U_\infty^2 a$

(C) $3\pi\rho U_\infty^2 a$ (D) 0

- a
- b
- c
- d

No, the answer is incorrect.
Score: 0
Accepted Answers:
d

15) The hydrodynamic lift force on the Rankine body per unit depth perpendicular to the plane if $q = \pi U_\infty a$ is *1 point*

(A) 0 (B) $3\pi\rho U_\infty^2 a$

(C) $\pi\rho U_\infty^2 a$ (D) $6\pi\rho U_\infty^2 a$

- a
- b
- c
- d

No, the answer is incorrect.
Score: 0
Accepted Answers:
a